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short communication

Mite infection of *Carabus violaceus* in rural forest patches and urban parks

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List of abbreviations:
C. violaceus = *Carabus violaceus*
M. glaber = *Macrocheles glaber*
P. carabi = *Poecilochirus carabi*
p = significance level

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Abstract

Background and purpose *We investigated phoretic mite (Acari: Mesostigmata) infection of* Carabus violaceus *(Coleoptera: Carabidae) in rural forest patches and urban forested parks in and around Debrecen city, Hungary. We hypothesized that the prevalence of mite infection, mean abundance, mean and median intensity of mites is higher in rural forest patches than in urban parks.*

Materials and methods *We collected* C. violaceus *individuals using live-capture pitfall traps and preserved them frozen. We identified and counted each mite of the host beetle individuals. Chi*^{2}*, Bootstrap t-test, Mood's median test were used.*

Results *We trapped altogether 199* C. violaceus *individuals (101 in the rural forest patches and 98 in the urban parks). There were 250 phoretic mite individuals on the* C. violaceus *representing two species (*Poecilochirus carabi, Macrocheles glaber*). We found 224 mite individuals in the rural forest patches, and 26 in the urban parks. We found that the prevalence, mean abundance, mean and median intensity of phoretic mites were significantly higher in the rural forest patches, than in the urban parks.*

Discussion *The studied phoretic mite species use beetles only for transfer and not harming them. Thus, the prevalence and mean intensity of these species depend primarily on the number of available prey density. The cause of decreased number of these phoretic mite species in the urban forest patches should be investigated in more details analysing the effect of disturbance due to urbanisation on a mite fauna and evaluating mite infection on carabids as potential bioindication of habitat disturbances or degradation.*

INTRODUCTION

Cities are densely populated, built-up, developed and often highly disturbed areas, with isolated fragments of the original habitats *(1, 2)*. These remnants of the original habitats are markedly different from the natural ones; they are usually warmer and drier than the original habitats *(3)*; thus, they are partly inhospitable habitats for the native species adapted to the local environmental conditions *(4)*.

Ground beetles are excellent ecological indicators; numerous studies focused on their responses to urbanization and human disturbance *(5, 6)*. Most of the papers concentrate on the assemblages, and do not examine the populations and/or individuals, but see *(7)*. There is some information about life cycle of ground beetle species *(8)*, but there is a gap in our knowledge about their interactions with mites.

The studied host species was *Carabus violaceus* Linnaeues, 1758. The average body size of this species is 28.0 mm in this region *(9)*. This beetle

is an eurytopic, mesophilic, flightless, brachypter species. Wings are reduced, elytra are fused. Its surface is black, lateral margins of pronotum and elytra are more or less blue, purple or violet *(10)*. This is a forest species, which is abundant not only in the rural forest patches but also in the urban parks *(4, 7)*. This beetle is a nocturnal predator, the ratio of its day activity is less than 15% *(11)*. During the day it can be found resting under woods, stones or leaf litter. It consumes mainly slugs, snails, various ground-living insects and their larvae, spiders, earthworms. The larva is also predator, although less swift than the adult form. The seasonal activity depends on the regions and altitude *(12)*. Most larvae hibernate and adults appear at the end of spring and reproduce in summer. Generations overlap.

Mesostigmata is one of the most diverse taxa of mites. The adult of several species are predators, consuming mainly fly eggs, larvae and nematodes *(13, 14)*. The nymphs are common phoretics of carabids and other beetles, using them for transport *(13)*. Phoresy means that mites attached to the beetles exclusively for transport. They are causing no harm for the host, although they may hamper them in motion.

The aim of our study was to explore phoretic mite infection of *Carabus violaceus* in rural forest patches and urban parks. The following hypotheses were tested: (i) the prevalence and mean abundance of phoretic mites are higher in the rural forest patches than in the urban parks. (ii) The mean and median intensity of phoretic mites also higher in the rural forest patches than in the urban parks.

MATERIAL AND METHODS

Study area and sampling design

The study area was in and around the city of Debrecen (Eastern Hungary). All selected areas were in a once-continuous old native oak forest association (*Convallario-Quercetum roboris*). There were two sampling area, a rural forest and an urban forested park. In the rural area there were no buildings and roads. In the urban area the built-up area exceeded 60%. The selected species was collected at each area using live-capture pitfall traps, randomly placing 20 traps at least 10 m from each other at each site. Traps were emptied daily from the beginning of May until the end of October in 2010 and 2011. There was no bait in the traps. All trapped *Carabus violaceus* individuals were separated from each other, and the beetles with their mites were preserved frozen. Mites were identified to species level using standard keys *(15, 16, 13)*. The mites on surface and in subelytral cave were counted and preserved in 70% ethanol.

Data analyses

Prevalence of mite infection, mean abundance of mites, mean and median intensity of mites were calculated. Prevalence is the proportion of infected individuals in the sample. Mean abundance is based on all the trapped individuals. Calculation of the mean and median intensity is based on only the infected individuals.

Chi^2-test and Mood's median test were used to compare the prevalence and the median intensity of the rural forest patches and the urban parks. Bootstrap t-test was used to test differences in the mean abundance and mean intensity of phoretic mites. During the calculations QP 3.0 were used *(17)*.

RESULT

During the study we trapped altogether 199 *C. violaceus* individuals; there were 101 individuals in the rural forest patches and 98 individuals in the urban parks. We found 224 phoretic mite individuals on *C. violaceus* in the rural forest patches, and 26 phoretic mite individuals on *C. violaceus* in the urban parks. Two phoretic mite species were found on the studied ground beetles: *Poecilochirus carabi* (44 individuals), and *Macrocheles glaber* (206 individuals). The prevalence, mean and median intensity of phoretic mite species were significantly higher in the rural forest patches than in the urban parks (prevalence: $p<0.005$, Chi-square statistic = 49.044, d.f. = 1; mean intensity: Bootstrap p-value (two-sided) = 0.005, t-statistic = –3.34; median intensity: exact p-value (two-sided) = 0.034) (Table 1). The mean abundance of phoretic mite species was also significantly higher in the rural forest patches (mean abundance: $p<0.01$, t-statistic = –7.25) (Fig. 1).

Table 1. *Number of hosts and their infection in the rural forest patches and urban parks.*

	No. of hosts			Intensity	
	Total	Infected	Prevalence	Mean	Median
Rural forest patches	101	62	61.4%	3.61	3.0
Urban parks	98	13	13.3%	2.00	1.0

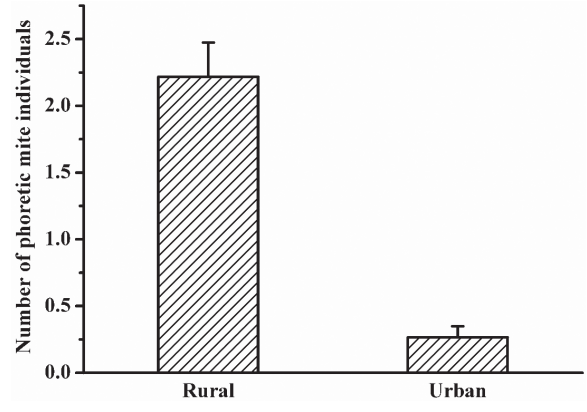

Figure 1. *Number of phoretic mite individuals per host in the rural forest patches and urban parks (mean ± SE).*

DISCUSSION

There are only few data published about the Hungarian Mesostigmata fauna *(18)*. During this study we identified two phoretic mite species (*Macrocheles glaber*, and *Poecilochirus carabi*) on the studied host beetle (*C. violaceus*). The development of these mites takes a few days, usually 3 days *(14)*. The nymphs use the beetles only for transfer and they do not harm directly the host species. The adult forms of these mites are free-living predators and feed mainly on fly eggs and first instar larvae. The female of *M. glaber* and *P. carabi* can destroy more than 13–18 fly eggs a day *(14, 19)*. There are only a few published data about the potential prey abundance *(20)*. In most cases they found that the abundance of Diptera species decreased towards the urban area *(20)*, but most papers concentrate only one species or families of flies.

Both of our hypotheses were confirmed. In the urban parks the mean abundance and prevalence of phoretic mites were lower than in the rural forest patches. A possible reason is that the abundance of these species rather depends on the number of potential prey individuals than on the viability of *C. violaceus (20)*. Furthermore, it is also important to note that *P. carabi* prefers the carrion beetles for transfer. Carabids usually infected by not only phoretic mites, but also by Astigmata mites. Several species of the Astigmata mites are paraphagous; and they are obligate external or subelytral paraphages of adult beetles *(13)*. Distribution of these mites may influence the feeding and reproduction of carabids. Thus, it would be necessary to know more facts about the roles of mites influencing the distribution of carabids and other arthropods.

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